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Twenty-eighth day of September 2005

LEANNE MYNOTT
MANAGER EXAMINATION SUPPORT AND SALES

ROCK-BOLTING APPARATUS AND METHOD

Background of the Invention

This invention relates to a rock-bolting apparatus and method.

This invention has particular but not exclusive application to a rock-bolting apparatus and method for use in mine construction, and for illustrative purposes reference will be made to such application. However, it is to be understood that this invention could be used in other applications, such as general tunnel construction, underpinning and the like.

Prior Art

Underground mining of mineral ores, such as coal and hard and soft rock mining requires the 'development' of underground drives in the form of tunnels. In all hard-rock applications, drive development is achieved through a drilling, charging, blasting, and mucking cycle. In the drilling stage of the cycle, a pattern of holes is drilled into the blind end of the drive. The holes are generally parallel to the drive axis. Typically, holes are 2-4 metres deep.

In the charging stage, explosive is placed in the drilled holes and connected via a detonating arrangement. In the blasting stage the explosive is detonated, the resulting blast fracturing the solid rock. In the mucking stage a front-end loader digs the fractured rock and removes it for hoisting to the surface via skips. This development cycle is well understood and is currently the most cost effective means of developing drives in hard rock.

An unavoidable consequence of this proven method is rock fracture beyond the desired geometric shape of the tunnel cross-section. This rock fracturing can cause the tunnel roof or back and/or the drive's side walls to be unstable. Rock

fragments large and small can disengage from the back and sidewalls and fall under the influence of gravity. Particle size ranges from microscopic to cubic metres. Falling particle larger than a tennis ball can prove fatal to personnel.

To protect miners from larger falling particles, a rock bolting/meshing procedure is applied. The process requires drilling holes 2-4 metres long in the 'back' (walls and overhead), and holding square mesh, typically 50 mm x 50 mm to 150 mm x 150 mm apertures, against the 'back'. Rock bolts and retaining plates are inserted through the mesh and into the drilled holes. Larger particles are restrained from falling by the rock-bolts and smaller particles are retained or caught by the mesh.

Rock bolts come in various style and each style is available in a range of lengths. Common styles include the clip set type where long slotted tubes grip the drilled hole via radial springing action along the entire length of the bolt. These bolts rust away in time and jeopardize long term security. The wedge-lock type is a bolt with an expanding tip, the locking action being controlled by screwing action. The gripping is at the blind end of the hole only. These bolts also rust away in time and jeopardize long term security. Epoxy grouted systems utilize a two-pack epoxy sausage which is inserted into the drilled hole. The bolt is inserted via a rotating action which mixes the epoxy. Curing a rapid usually about 35-60 seconds. Grip is along the entire length of the bolt. These bolts resist corrosion. Cement grouted systems are also used.

Rock-bolting/meshing equipment comes in two broad groups, comprising purpose built drilling, bolting machines and adaptations of twin boom development heading 'jumbo' drills. The purpose built drilling, bolting machines generally feature

three parts, being a transport vehicle subassembly, a multi-axis support arm mounted thereon and a drilling and bolting mechanism on the support arm. The drilling and bolting mechanism contains many functions and is relatively heavy, both for robustness and to provide inertial stability. The multi-axis support arm, while capable of supporting the mechanism, tends to deflect, has low natural frequencies of bobbing up/down and back/forth and also has poor 'fine control'. The transport vehicle is rubber tyred, with articulated steering, diesel powered and with front jacks for vehicle stability while working.

In use, problems arise because of the physical properties of the freshly fractured rock surface. It is uneven and fractured, presenting a myriad of randomly oriented faces. Lighting from the vehicle throws this surface into stark black/white features where the operator cannot determine the inclination of faces to select a stable face for drilling.

Collaring is the step of the drill taking purchase and commencing the new hole and usually describes the first 0-20 mm of drilling. The drill head is a blunt steel arrangement with embedded tungsten carbide tips, air/water cooled and purged via a central hole along the drill steel. Cutting is by rotation and impact from the drill, typical drilling being at 1-2 metres per minute. When the blunt drill head strikes an angled rock face in attempting to collar a new hole, it cannot achieve penetration. The drill slides down the face until it finds purchase in the 'valley' between two intersecting planes of the rock faces. Collaring now proceeds as does the remainder of the hole drilling.

The drill bit, sliding down the rock face and into the 'valley' demands lateral compliance since the support arm's hydraulics have not yielded or adjusted.

Compliance is available from many sources including elastic bending of the drill steel, mechanical play or hackles in the drill steel/drill interface, the drill/drill slide interface and every other mechanical junction, deflection in the supporting arm, and deflection in the supporting vehicle.

The drill achieves a collared and drilled hole, albeit not precisely where the drill was aimed. Upon drill steel extraction form the new hole, the elastic compliance is released and the whole machine wobbles back and forth, finally settling with the drill steel axis no longer aligned with the freshly drilled hole. The mechanism now increments, removing the drill from the axis and replacing it with the bolt magazine and inserted. The bolt has little chance of finding the hole because the mechanical 'slop' (play, clearance, backlash) is endemic, with machine parts which are expected to operate reliably despite spending their lives in a shower of water, grit and falling rocks. The net effect is that the drill will often not be co-axial with the bolt. Rock fragments often fall from the 'back' around the freshly drilled hole to sit on the mesh, masking the hole. Attempting to insert an all metal bolt is normally unsuccessful. The machine operator then gets out of his protected cabin and walks under the unprotected, freshly fractured, freshly drilled ground to try and find the offset error between where the hole axis lies and where the bolt axis lies. This is the most dangerous time with a high risk of falling rock causing death or injury. The operator goes back to his machine and tries to remember the direction and distance of the offset and, using an arm with poor 'fine control', attempts to adjust for the error. There are often several attempts to be made to adjust for bolt insertion. With epoxy grouted bolts, these aiming problems can see the two-part epoxy sausage bursting,

covering the drilled/bolting mechanism with rapidly setting epoxy, which can disable the mechanism.

The twin boom jumbo solution goes part way toward alleviating the inherent difficulties and dangers associated with meshing drives. The key advantage of the twin boom jumbo is that only one piece of equipment is required to a given drive heading. The miner can drill, blast and roof-bolt with the jumbo. In the jumbo roof bolting methods to date, bolt selection is limited to non-grouted bolts. For short-life development loadings into mass-blast steps area, this is not a problem. For long life drives eg. declines, this is be a problem because of the aforementioned bolt corrosion. Generally, the right boom carries the mesh sheet up to the back, hanging from the drill steel. The left boom carries the bolt and inserter in the form of the left boom drill drive, and orients the mesh against the back. The hole is drilled via the right arm. The right arm then holds the mesh, away from the freshly drilled hole. The left arm travels and, being aligned by eye from the machine, inserts the bolt into the freshly drilled hole. Once one bolt is inserted, the mesh sheet is self supporting. It is necessary for both jumbo drills to be aligned prior to drilling to ensure the axes of the drilled and bolting mechanism were basically parallel. With high operator skill levels, this method, used in ground with reasonable surfaces, proves reasonably efficient.

The major disadvantages are the high operator skill required, and the bolt type limitations. The major advantages are that only one piece of equipment is required.

The present invention in one aspect resides broadly in rock-bolting apparatus including carriage means, boom means mounted on said carriage means and adapted to extend to engage opposed wall portions of a drive to be secured, drilling

means associated with one end of said boom means, and rock bolt installation means associated with said boom means.

The carriage means may take any form usual in providing underground rock mining equipment. For example, the carriage means may comprise diesel, electric or hydraulically operated plant, mounted for movement on any suitable undercarriage such as tracks, wheels or rails.

The boom means may comprise a fixed length boom having extending elements mounted thereon or may comprise a telescoping arrangement. The extension of the boom is preferably hydraulic in operation. The boom may be configured to be movable in one or more of azimuth, elevation or slew by mountings comprising either fixed pivot and/or lost motion apparatus.

The carriage means preferably includes a rated safety cell or cage for the operator. The safety cell or cage may be configured to slew with the boom, whereby the operator may observe the operation of the apparatus from a fixed perspective.

The boom is preferably configured whereby the operator may perform the drilling operation from a position where the safety cell or cage is located beneath a prior-stabilized portion of the drive or tunnel. The boom preferably comprises an articulated boom assembly whereby the drilling and bolting operations may be conducted over the maximum circumferential and axial extent in the drive.

In one embodiment the boom assembly comprises a primary locating assembly on the carriage adapted to position the extending boom and an advancing arm assembly providing the drilling means and the bolting means wit the necessary advance in operation. The primary locating assembly may comprise a slewing base on the carriage means to which is hinged a primary arm, the angular relation of the

arm to the base being constrained by a ram. A further arm may be hinged to the first arm (the respective hinges being parallel) and operable relative thereto by a second ram, the two arms and slewing base being co-operable to provide vertical and horizontal extension as well as slew for the outer end of the second arm. A yoke may be pivoted to the outer end of the second arm by a further parallel pin, the yoke being orthogonal thereto and adapted to provide working articulation of the advancing arm assembly which provides the advance and retract for the drilling and bolting operations. The working articulation is preferably rotational about an axis perpendicular to the yoke pin to provide the circumferential traverse about the overhead of the drive as well as about the yoke pin to provide lateral travel in complement with the slew to allow the drilling to be done perpendicularly to the drive wall surface.

The drilling means may be mounted on or within the boom means. For example, the drilling means may be mounted within the means providing engagement of the boom assembly with the drive wall whereby the drilling rod thereof extends through one or more of the means provided for engagement of the boom assembly with the wall of the drive. Alternatively the drilling means may comprise a separate assembly wherein means providing engagement of the boom assembly with the drive wall does not of itself provide the passage for the drill bit, although the boom end may be configured whereby a drilling means operates in parallel with the boom means and passes through an aperture on the boom end.

The drilling means is preferably configured on said working articulation whereby the drilling means and boom means move in concert to maintain a parallel interrelation in use. To this end, the drilling means and boom means are preferably

mounted to said working articulation on a common base. The drilling means may comprises a multi-link drilling arm pivotally mounted to the common base and mounting a drilling head adapted to receive the drill bit. The multi-link drilling arm is preferably configured to have multiple modes of operation, such as to provide a longer stroke for blast hole drilling and a shorter stroke for drilling and bolting the overhead, thus accommodating the different imperatives of space in use and in stowage. The stowage issue may be particularly important where the apparatus as a whole must be turned in a restricted turning circle in the drive.

The means providing engagement of the boom assembly with the drive wall may take any suitable form. For example the engagement means may comprise one or more engagement spiked or ridged portions associated with the respective ends of the extendible boom means. Preferably, at the drilling end of the boom there is provided an array of spikes about the drilling axis. The boom means may be mounted on the common base with the drill means as described above. In one embodiment, the boom means comprises a boom assembly the lower portion of which forms the common base and integrally extends therefrom to a telescopic

There may be provided a pilot guide means associated with the drilling means and adapted to provide an initial guide for the drilling rod to collar the hole. The pilot guide means may be selected to remain in position for one or more of the drilling, grouting and bolting functions of the apparatus. The pilot guide means may be selected to work in concert with, or in fact be, the means providing engagement with the drive wall. The pilot guide means may for example comprise a conical or other tapered solid section having a hole bored therethrough to admit the drill rod whereby

the terminal minor section engages and stabilizes the collared hole for drilling and bolting, with or without grouting.

Alternatively, the pilot guide means may be dispensed with and the drill may pass though a clearance aperture in an end assembly on the boom adapted to pass in turn the drill and the bolt including the head of the bolt. In this embodiment the end assembly may include rock wall engagement elements such as spikes or ridges. If desired the end assembly may be provided with deployment means for washer plates which deployment means may be configured to operate in synchronization with the bolting step to interpose a washer plate between the rock wall and the end assembly between the engagement elements. The washer plates may be supplied from a stacking magazine associated with the boom end, and having feed means adapted to a feed washer plate from the magazine to a position indexed with the drilled hole, in synchronization with the rock bolt installation means delivering the bolt into the drilled hole.

The rock bolt installation means associated with said boom means may take any suitable form and will generally be determined as to configuration by the boom arrangement and drill means arrangement. Preferably, the rock bolt installation means is mounted on the boom means and is configured to cooperate with the drill means by way of moving into index with the drilled hole as the drill means is moved out of index therewith. The rock bolt installation means may be provided with a magazine containing a plurality of bolts such as a rotary magazine. Alternatively, the magazine may comprise a box or drum magazine wherein the bolts are arranged in a disintegrating link belt, rubber link belt or webbing belt assembly, and wherein feed

means is provided to deliver the belt, index the next bolt and extract or displace the bolt from the belt in the insertion stroke of the apparatus.

The rock bolt installation means may include means for rotating the inserted bolt into the hole. Preferably the rock bolt installation means comprises a bolt delivery mechanism adapted to deliver the bolts into register with the aforementioned clearance aperture in the boom end, whereby the drive means for the drill may then be utilized to drive the bolt into the pre-drilled hole, with or without rotation according to the bolt type.

Where required the rock bolt installation means may also include a grouting sausage installation arrangement whereby a grout sausage may be inserted in the drilled hole ahead of bolt installation. The rock bolt installation means may be configured to apply rotation with insertion of the rock bolt, either during insertion or at the end of insertion, depending on the bolt type used.

The apparatus preferably includes a mesh supply and delivery means therefor whereby the drilling, meshing and bolting functions may each be addressed by the operator from the carriage safety cell or cage. For example there may be provided a spindle mounted mesh roll on an articulation capable of presenting and deploying the mesh ahead of the drilling program. The deployment may be in large areas, but it is preferred that deployment occurs progressively with rock bolt installation. The mesh may be deployed in panels as an alternative to a roll with cutter.

The mesh may be contained in a mesh box which may be mounted on the apparatus or towed separately. The mesh box may be provided with a delivery slot, through which the mesh may be delivered by drawing out or by means associated with the box for delivering the mesh. The delivery slot may be provided with shearing, grinding or thermal cutting means for the mesh.

The apparatus may also include other functions such as descaling wherein an articulation means mounts a rock hammer to dislodge loose material from the drive walls ahead of meshing. The articulation means may be separate form the mesh supply and delivery means, and the boom means, or alternatively the articulation means may comprise an additional function of one or the other of the mesh supply and delivery means, and the boom means. In one embodiment of the present invention, the additional functionality is provided by a second drill, that may be used to drill ahead as well as a descaling implement. Preferably the descaling operation is conducted while the safety cell or cage is located under a supported portion of the drive.

In a yet further embodiment, there may be provided more than one boom assembly in accordance with the present invention on a single carriage. For example the conventional twin boom jumbo chassis may form the carriage of the present invention and mount two drilling and bolting assemblies on respective primary arm assemblies. By this means, the apparatus may be configured that at any one time there is drilling and bolting occurring, thus providing for efficiency even when the drilling and bolting are being done sequentially on each arm.

In a further aspect this invention resides broadly in a method of securing the walls of a drive or the like and including the steps of providing carriage means adapted to be located within a supported portion of said drive and having boom means mounted on said carriage means, extending said boom means to engage opposed unsupported wall portions of said drive, drilling holes in one said unsupported wall portion with drilling means associated with said boom means, and installing rock bolts in said drilled holes with rock bolt installation means associated with said boom.

The invention will be further described with reference to the drawings illustrating a preferred embodiment of the present invention and wherein:

FIG. 1 is a perspective view of apparatus in accordance with the present invention in descaling use;

FIG. 2 is a perspective view of apparatus in accordance with the present invention in use;

FIG. 3 is a perspective detail view of apparatus in accordance with the present invention in use;

FIGs. 4 to 7 are progressive operation views of the detail of FIG. 3;

FIG. 8 is a perspective view of an alternative embodiment of apparatus in accordance with the present invention, in use;

FIG. 9 is a further perspective view of the apparatus of FIG 8, in use;

FIGS. 10A-C is a partial perspective view of the apparatus of FIG 8, showing sequential deployment of the boom;

FIG. 11 is a partial perspective view of the apparatus of FIG 8, showing deployment of the drilling assembly;

FIG. 12 is a partial perspective view of the apparatus of FIG 8, showing deployment of the bolting magazine assembly;

FIGS. 13 A-G is a partial perspective view of the apparatus of FIG 8, showing sequential assembly of the slewing primary arm assembly;

FIGS 14 A-C are sequential side views illustrating short drilling/bolting operation of the boom/drill means of the apparatus of FIG 8;

FIGS 15 A-D are sequential side views illustrating long drilling operation of the boom/drill means of the apparatus of FIG 8;

FIG 16 is a perspective view of the apparatus of FIG 8 deployed for blast hole drilling using the long drilling operation of FIG 15;

FIGS. 17 A-C is a partial perspective view of the apparatus of FIG 8, showing sequential deployment of bolt magazines;

FIG 18 is a perspective view of linked bolts and magazine for use in the apparatus of FIG 8;

FIG 19 is an end detail view illustrating the packed configuration of the bolts and magazine of FIG 18;

FIG 20 is a view of the washer plate and magazine assembly for use in the apparatus of FIG 8

FIGS 21 A-E are sequential illustrations of operation of a mesh magazine suitable for use in the apparatus of FIG 8; and

FIGS 22 A-B are perspective and plan view illustrations of the dynamic properties of the apparatus of FIG 8 in its stowed configuration.

In the figures there is provided a diesel-powered carrier 10 having a mesh handling assembly 11 and a drilling/bolting assembly 12 mounted thereon. The mesh handling assembly 11 comprises a hydraulically operated rotating mount 13 to which is articulated a primary arm 14. The primary arm 14 articulates a hydraulically operable extending arm 15 having mounted at its outer end a coiled mesh reel 16 having associated therewith a deploying drive and cutter (not shown). The coiled mesh reel 16 is detachable to be stowed on the diesel powered carrier 10, whereupon a descaling hammer 18 may be mounted on the extending arm 15.

The drilling/bolting assembly 12 comprises a hydraulically operated rotating mount 17 to which is articulated a primary arm 20. The primary arm 20 articulates a

hydraulically operable extending arm 21 having mounted thereon an articulated assembly carrier 22. The assembly carrier 22 forms an elongate housing for a hydraulically extendible telescopic brace 23 adapted to extend from one end of the assembly carrier 22. On the other end of the assembly carrier 22 is provided a drill assembly 24. The drill assembly 24 comprises a drill guide assembly 25 of conical form having a guide bore 26 formed therein, the drill guide assembly being divided about its conical axis to form guide halves 27. The guide halves 27 are formed on struts 30 that are mounted in inclined bores on a guide carrier 31, whereby advancement of the struts 30 closes the guide halves 27 up to provide a drill guide in contact with a rock wall, and retraction of the struts 30 opens and retracts the guide halves 27 against the guide carrier 31. The guide carrier 31 has a bore 32 formed therein that is coaxial with the guide bore 26. A hydraulically operable drill 33 mounts a drill bit 34 coaxially with the guide bore 26 whereby the drill bit 34 may be advanced through the guide bore 26. A rotary magazine 35 is mounted on the assembly carrier 22 and carries several drill bits and rock bolts 36 which may be selectably moved into index with the axis of the guide bore 26. A grout delivery tube 37 is mounted on swinging clamps 40 whereby the grout deliver tube 37 may be moved in to and out of index with the guide bore 26. The drill bit 34 may be advanced to provide for insertion of the grout delivery tube 37 into a formed hole through the guide bore 26. The grout delivery tube 37 is supplied with grout composition or grout sausages through a flexible tube 41leading from the diesel powered carrier 10. A pair of spaced engagement spikes 42 are mounted on the assembly carrier 22 whereby they may be hydraulically extended into engagement with the rock face, the reactive force of engagement being countered by engagement of the hydraulically extendible

telescopic brace 23 with the opposite face of the drive. The diesel powered carrier 10 supported on 4 corner mounted stabilizing jacks 43 to isolate the braced drilling/bolting assembly 12 from suspension compliance.

In use, the diesel powered carriage 10 is driven to the tunnel where the roof is to be secured; and parked under supported roof. The diesel powered carriage 10 is stabilized via the 4 corner mounted stabilizing jacks 43. The mesh handling assembly 11 first mounts the descaling hammer and descales the 'back' (roof). During descaling all other mechanisms are retracted and protected under the previously supported roof.

The mesh handling assembly 11 then picks up the coiled mesh reel that is stored on the machine. The reel is stored in a position that makes it possible to reload it from the rear. The coiled mesh reel is fitted with a means of unreeling the coil and a means of cutting the mesh once installed. The unreeling can be accomplished by powering the central hub of the roll or by passing the mesh between rollers. The cutting of the mesh can be by a guillotine action or cutting wheel. The coil is unwound so that a small sheet of coil is covering the beginning of the area to secure.

The drilling/bolting assembly 12 is then offered up to the mesh for installation of the first bolt. To secure the mechanisms during drilling, grouting and bolting the apparatus uses the telescopic brace in opposition to the two extendible spikes to lock the mechanism against opposite sides of the tunnel. The procedure is to extend the conical guide and position it against the rock face where the next bolt is required. The two extendible spikes are then extended to engage the rock face. The drilling/bolting assembly 12 can be rotated to position the spikes where they can be

well seated. The telescopic brace is then extended until it engages the opposite wall of the tunnel. The thrust from the telescopic brace is greater than the combined thrust of the two extendible spikes thus when full power is applied to all cylinders there is a net force seating the cone.

The drilling/bolting assembly 12 is now independent of the machine or machine arm flexibility and will remain as solidly positioned through the bolting cycle.

Once the drilling/bolting assembly 12 is positioned and secured for drilling as above the cone remains in contact with the rock. This provides an initial guide for the drill to prevent it from drifting and also secures the area around the hole. The cone then stays locked in position to provide a smooth transition for the epoxy, grout or bolt from the insertion mechanism into the hole. When the bolt is inserted into the hole and is being screwed or pushed in the cone retracts providing a clear path for the bolt capping plate.

Once the hole has been drilled the clamps swing the pipe to align it with the drill axis. The drill then engages the pipe and the clamps are released and retracted. The drill then extends without rotating inserting the pipe into the drilled hole. The rear of the pipe is connected via the flexible hose to a grout pump or an epoxy tube ejection unit. Epoxy tubes consist of a flexible plastic tube of hardener inside a flexible plastic tube of resin. These can be shot into the drilled hole through the pipe and interconnecting hose by compressed air. The operator places the epoxy tube into the ejection unit, which is accessible from the cockpit, and eject it once the pipe is extended into the hole. If grout were to be used the hose would be connected to a grout pump that the operator would control to fill the drilled hole once the pipe was inserted. The pipe would then be withdrawn leaving the epoxy tube or grout in the

hole. The pipe and hose once retracted are re-clamped, disengaged from the drill and swung clear.

The bolt/drill magazine is deployed by the two rams with bar clamps on their end. These are retracted to clear the bars allowing the carousel to index into position. The rams then extend and the end clamps clamp the bar or drill. The rams then extend pulling the bar/drill from its mount in the carousel and positioning it on the axis of the drill. The drill then engages the bolt/drill, the clamps release and retract, and the drill is free to extend and rotate as required.

In the embodiment illustrated in FIGS 8 to 22, there is provided a twin-boom jumbo chassis forming the carriage 50. The machinery platform 51 of the jumbo 50 mounts a pair of slewing bases 52. The slewing bases 52 each have a pair of spaced hard points 54 for pivotally mounting a primary arm lower member 55, the relative disposition of which is provided by a ram 56 disposed between the lower member 55 and a third hard point 53 on the slewing base 52. A primary arm upper member 57 is hinged to the lower member 55, and the relative disposition of the upper 57 and lower 55 members is controlled by a ram 60 disposed between the upper and lower arms.

The upper and lower arms operate in a vertical plane that can be slewed via the slewing base. A yoke 61 is pivoted to the outer end of the upper member 57 via a yoke pivot 62 having an axis substantially parallel to the articulation between the upper and lower members. The yoke 61 includes a trunnion portion 63 having a trunnion axis substantially perpendicular to the yoke pivot 62.

Articulated in the trunnion portion 63 is a tool mounting base assembly 64 including a tool mounting base 65 having a first mode of rotation in a plane parallel to

the trunnion axis and a second mode of rotation in a plane perpendicular to the trunnion axis.

A tool assembly 66 is supported on the tool mounting base 65 and comprises a common base portion 67 extending integrally into a boom body 70 and further mounting a power head assembly 71.

The boom body 70 has a forward end mounting a drive wall engagement portion 72 having an aperture 73 therethrough of dimension adequate to pass drills and bolts. The wall engagement portion 72 includes a pair of spaced wall engaging ridges 74 disposed about the aperture 73 and defining therebetween a channel 75. The channel 75 is in index with a washer plate magazine 76 disposed below the wall engagement portion 72 and is operable whereby a washer plate 77 may be displace from the magazine 76 into the channel 75 and into register with the aperture 73.

The boom body 70 further comprises a housing for a telescopic rear strut 80 which is adapted to be deployed to engage the drive wall opposite to the wall engagement portion 72 and thereby brace it into engagement with the drive wall during the drilling and bolting operations.

The boom body 70 has mounted thereon a tool and bolt handling assembly 81 comprising a pair of shaft mounted gripper arms 82 adapted to selectively engage either of a long 83 and short 84 drill bit, or rock bolts 85. The rock bolts 85 are presented to the gripper arms by bolt magazine 86 removably supported on the boom body 70 and having mounted therein a belt 87 comprising plurality of bolts 85 held together by links 90 whereby the bolts 85 may be sequentially disintegrated from the belt 87 by the gripper arms 82.

The power head assembly 71 comprises a motor 91 pivotally mounted on a two-link tool arm 92 pivoted to the common base portion 67 whereby the motor 91 may be selectively deployed along a line parallel with the boom body 70 and having its motor axis aligned with the aperture 73. The two-link tool arm 92 has an intermediate elbow 93 that may be deployed forward of the common base portion 67 to commence a short throw of the motor for drilling and bolting, and behind the common base portion 67 to commence a long throw for drilling blast holes in the advancing drive face 94, as illustrated in the respective sequences of FIGS 14 and 15. A view of the drive face drilling operation is also provided in FIG 16.

The motor 91 is fitted with an automatic chuck 95 adapted to receive in turn either of the drill bits 83, 84 or the rock bolts 85.

A consumables cart 96 comprises a wheel mounted mesh magazine 97 containing a mesh roll 100 which is led out through a feed and cutter assembly 101. The boom body 70 is adapted to engage the leading edge of the mesh roll 100 for deployment of the mesh in use. The consumables cart 96 has spare bolt magazines 86 which are collectable by the boom arm 70, as illustrated in the sequence of FIGS 17A to 17C. The carriage 50 is articulated at 102 in order to optimize the turning circle and maneuverability of the carriage 50, as illustrated in FIGS 22A and 22B. The carriage 50 includes locating jacks 103 adapted to remove the effect of wheel and suspension compliance on stability when drilling and bolting.

For travel, the slewing bases 52 are aligned with the primary arm lower member 55 and upper member 57 fully retracted in a fore-and-aft vertical plane. The telescopic rear strut 80 is fully retracted into the boom body 70 and the boom body 70

is rotated about the tool mounting base 65 to extend back in the direction of the carriage cab 104.

In use the apparatus is located for drilling and bolting as illustrated in the sequence of FIGS 10A to 10C, wherein (after engagement of the jacks 104) the primary arm 55, 56 locates the boom body 70 in concert with the tool mounting base 65 such that the drive wall engagement portion 72 is in contact with the drive wall at the desired position. The telescopic rear strut 80 is then extended to engage the drive wall opposite the drive wall engagement portion 72, thus essentially fixing the boom against movement.

It will of course be realised that while the above has been given by way of illustrative example of this invention, all such and other modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of this invention as is herein set forth.

CLAIM

1. Rock-bolting apparatus including carriage means, boom means mounted on said carriage means and adapted to extend to engage opposed wall portions of a drive to be secured, drilling means associated with one end of said boom means, and rock bolt installation means associated with said boom means.

DATED THIS EIGHTEENTH DAY OF JUNE, 2001.

RUSSELL MINERAL EQUIPMRNT PTY LTD

by

PIZZEYS

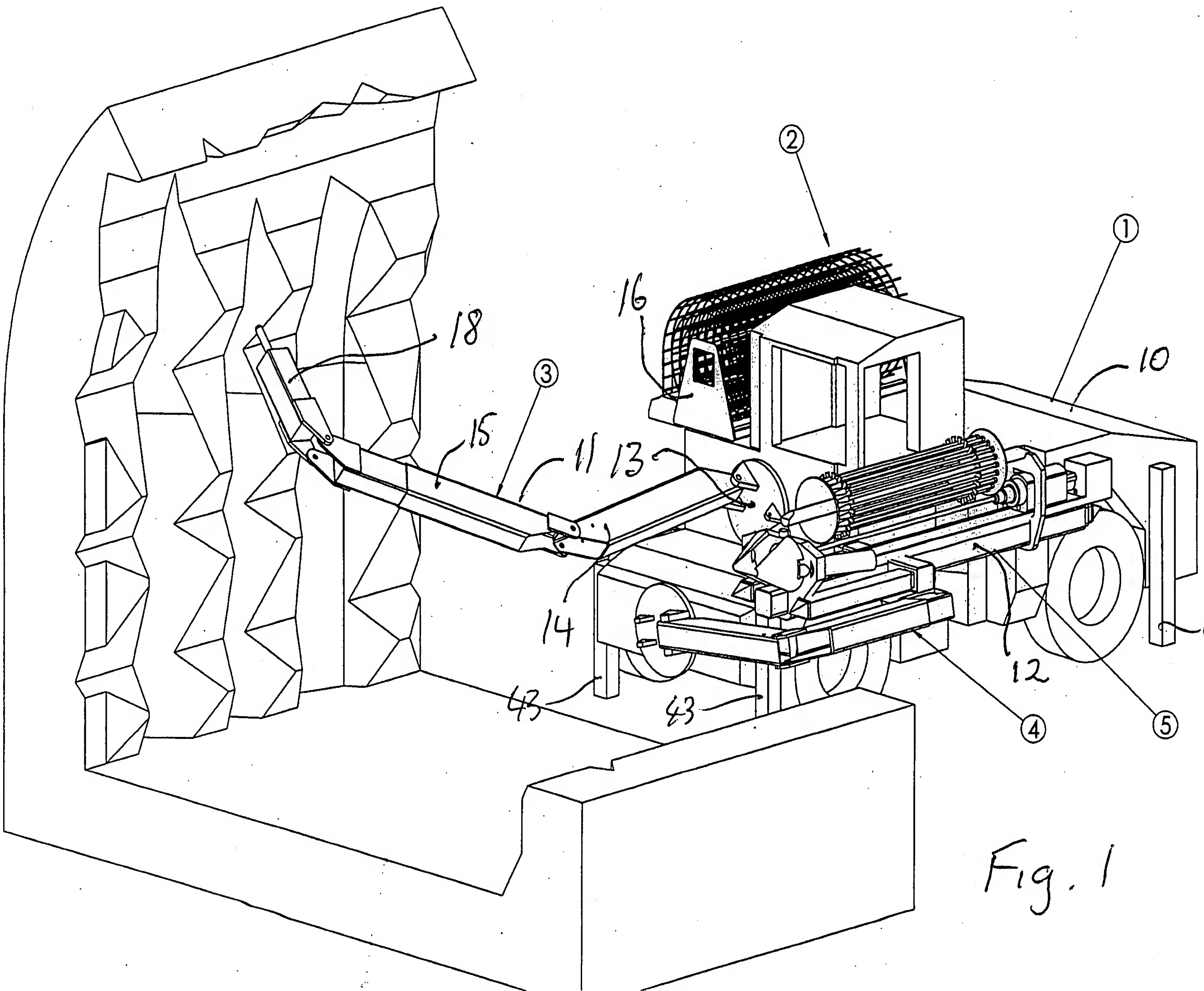


Fig. 1

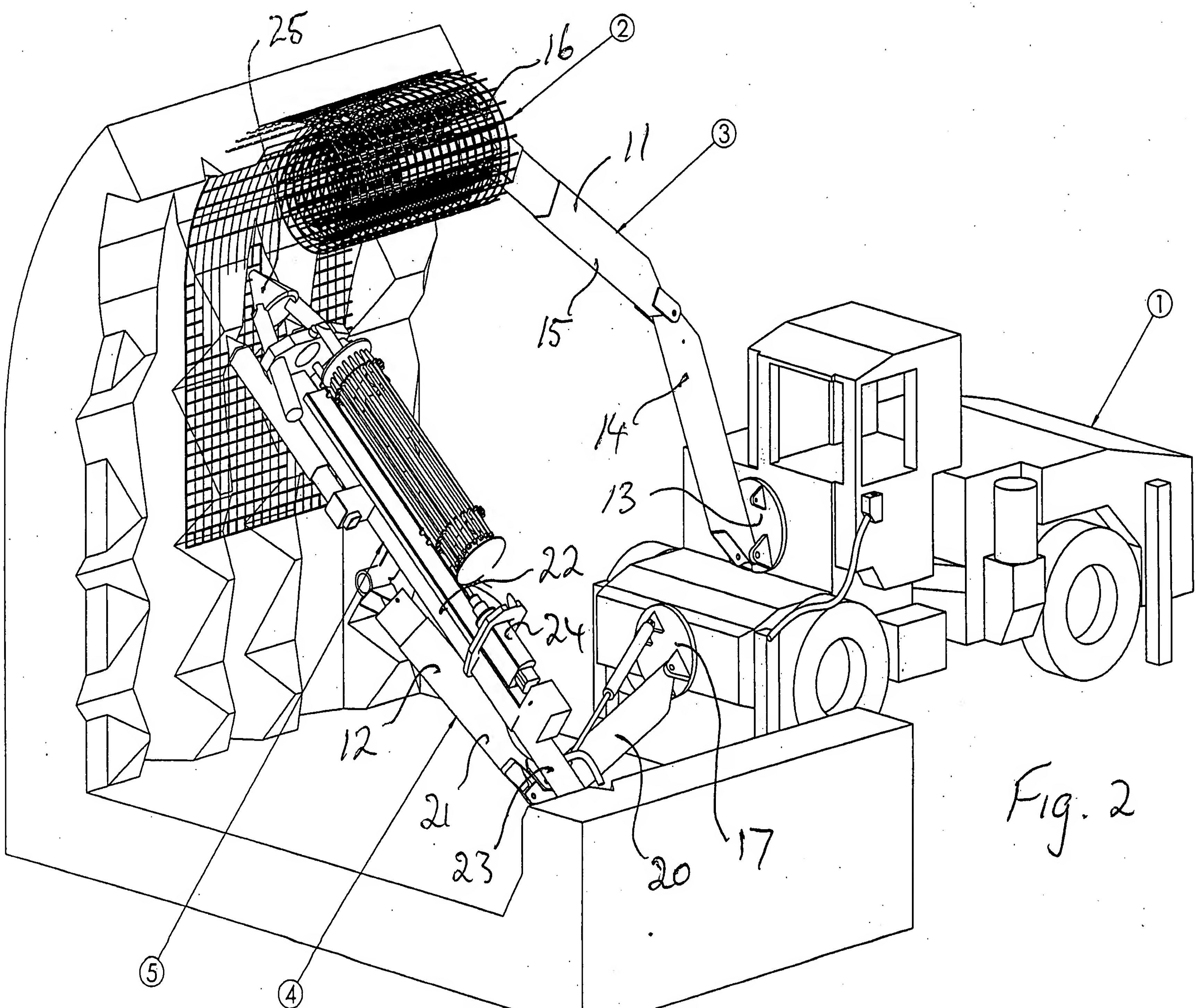


Fig. 2

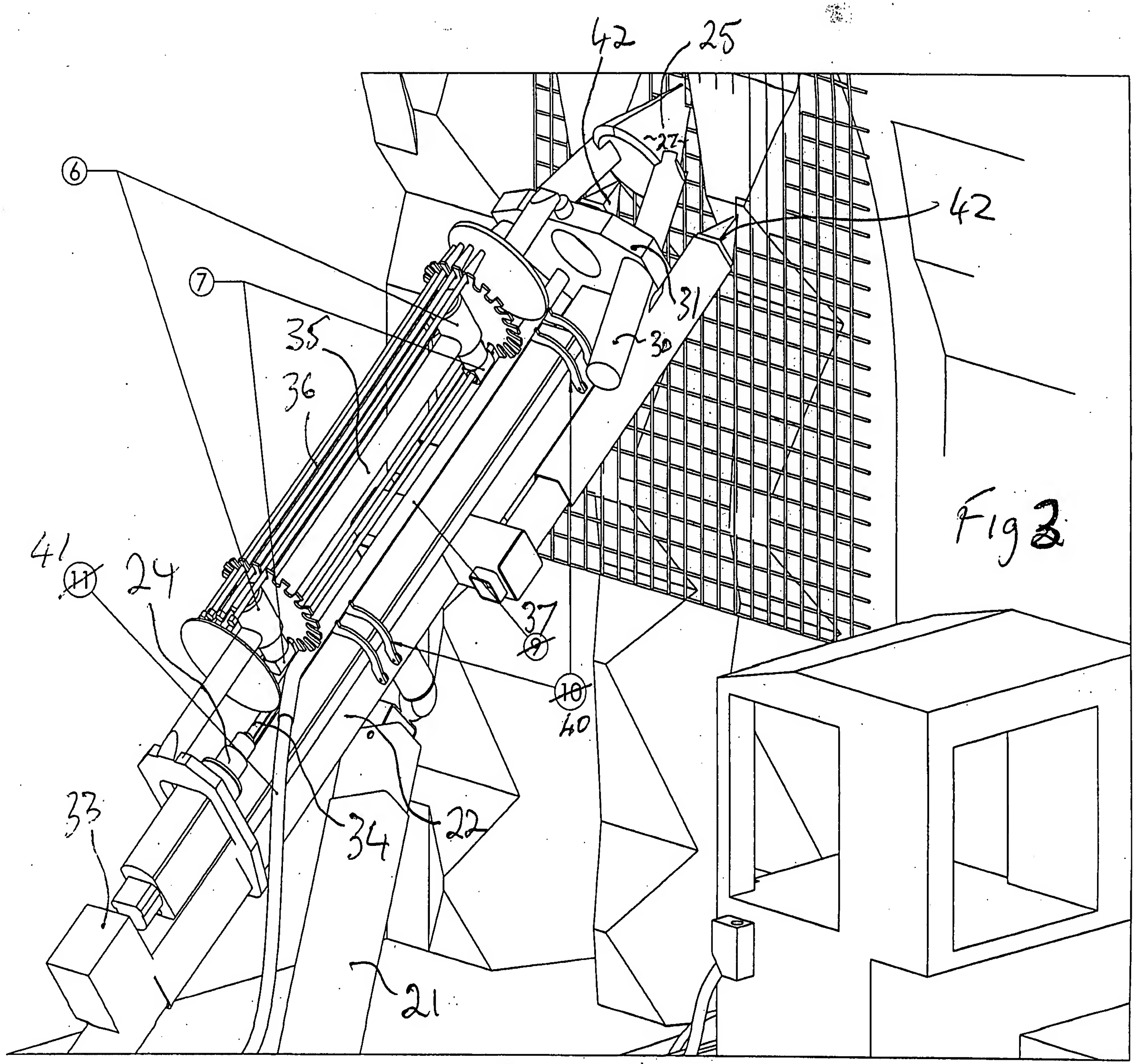
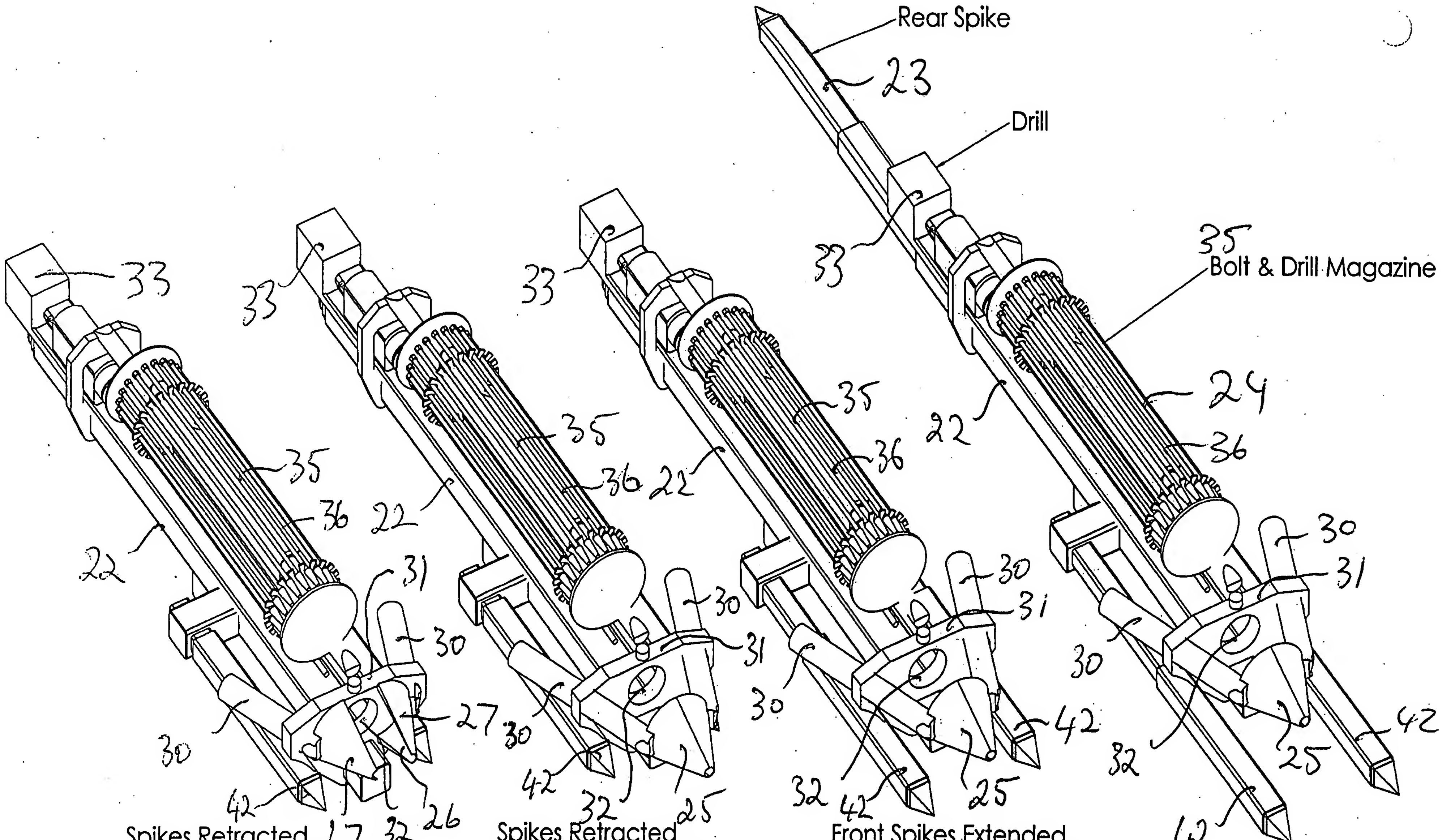


Fig 3

TRIDENT



Spikes Retracted
Cone Retracted and Open

Fig. 4

Spikes Retracted
Cone Extended and Closed

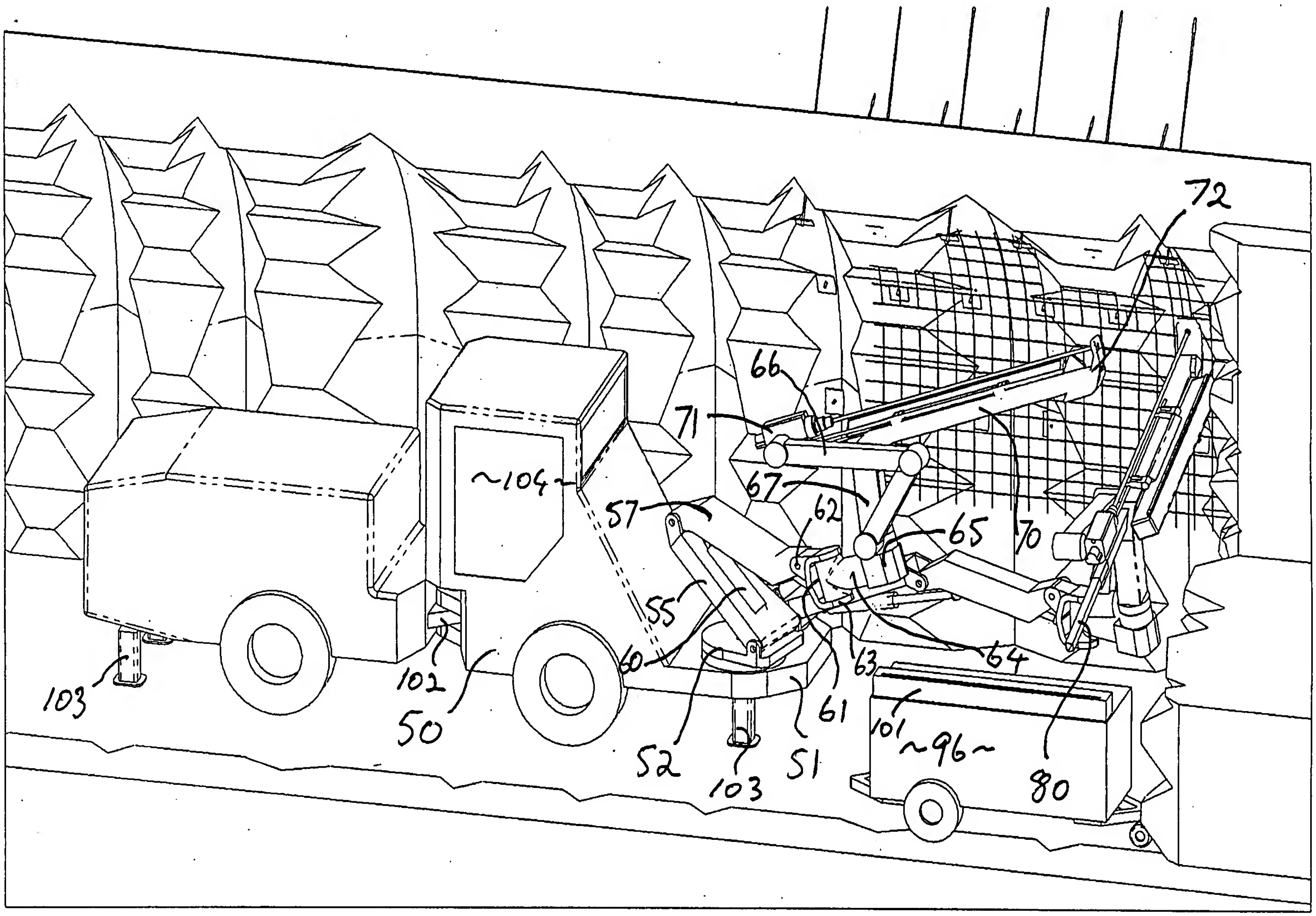
Fig. 5

Front Spikes Extended
Cone Extended and Closed

Fig. 6

Front & Rear Spikes Extended
Cone Extended and Closed

Fig. 7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80

FIG 8

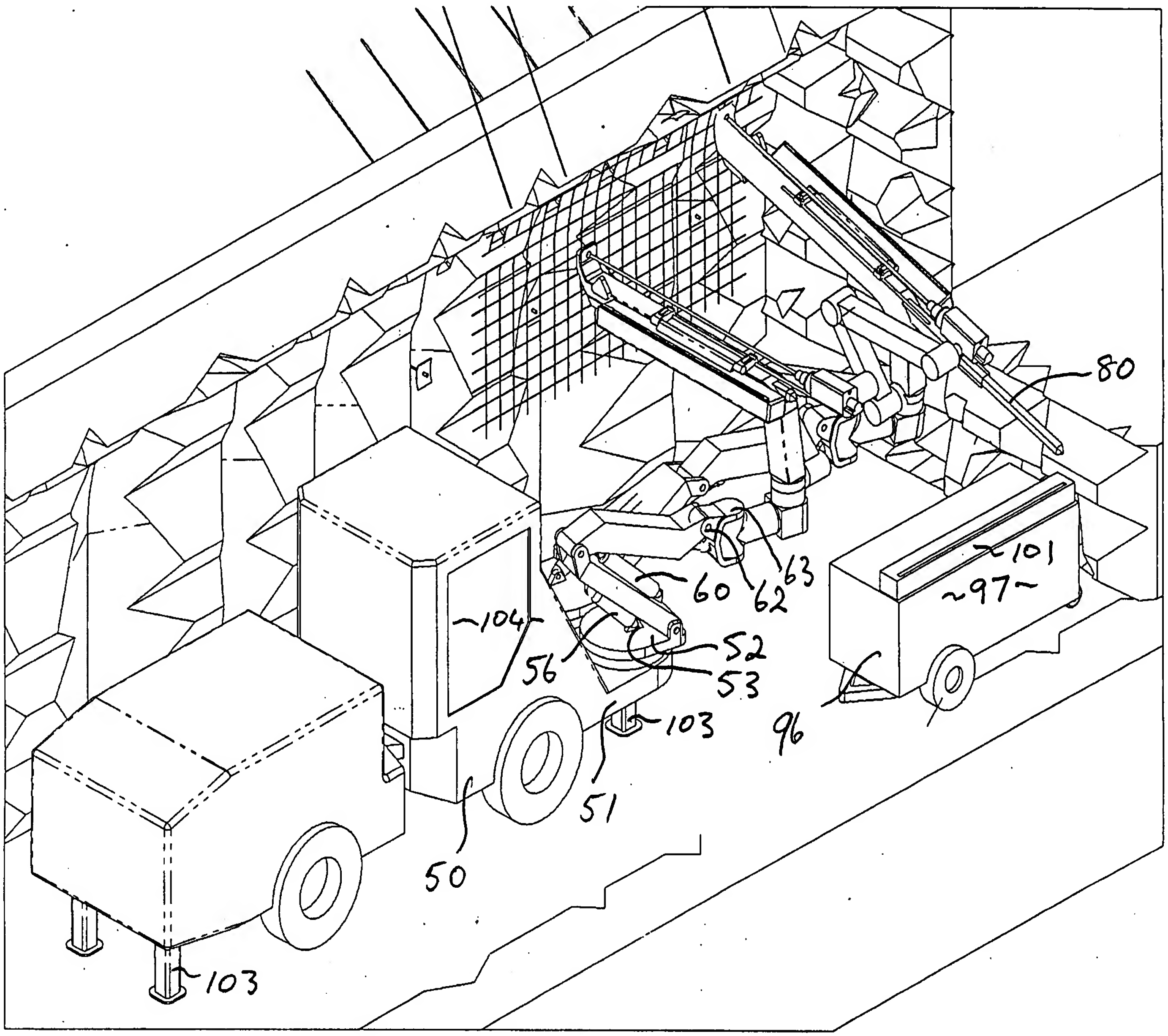

Fig 9

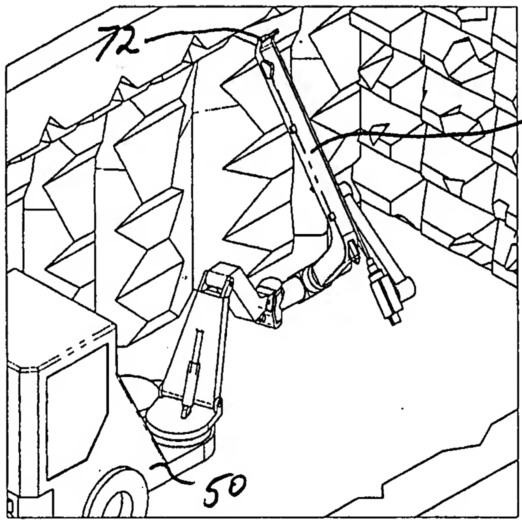

FIG 10A

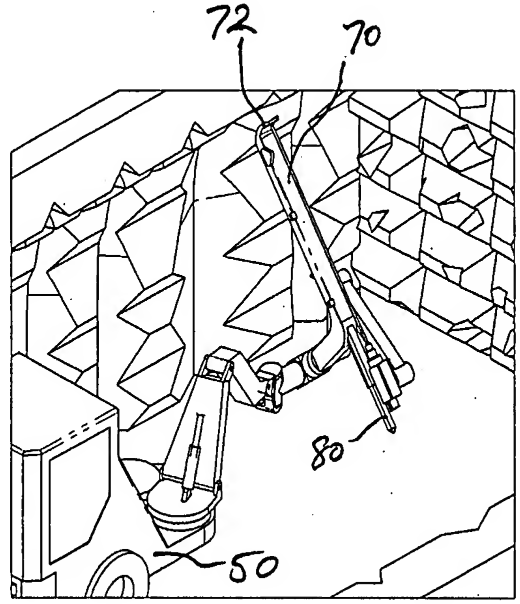

FIG 10B

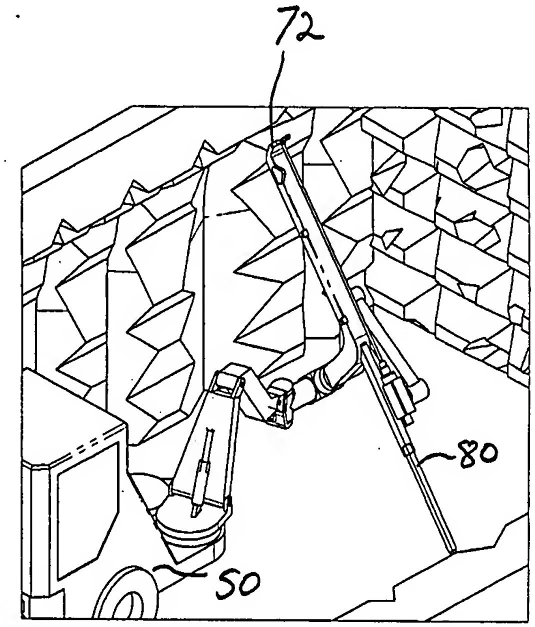

FIG 10C

"STINGER" SUPPORT ACTION

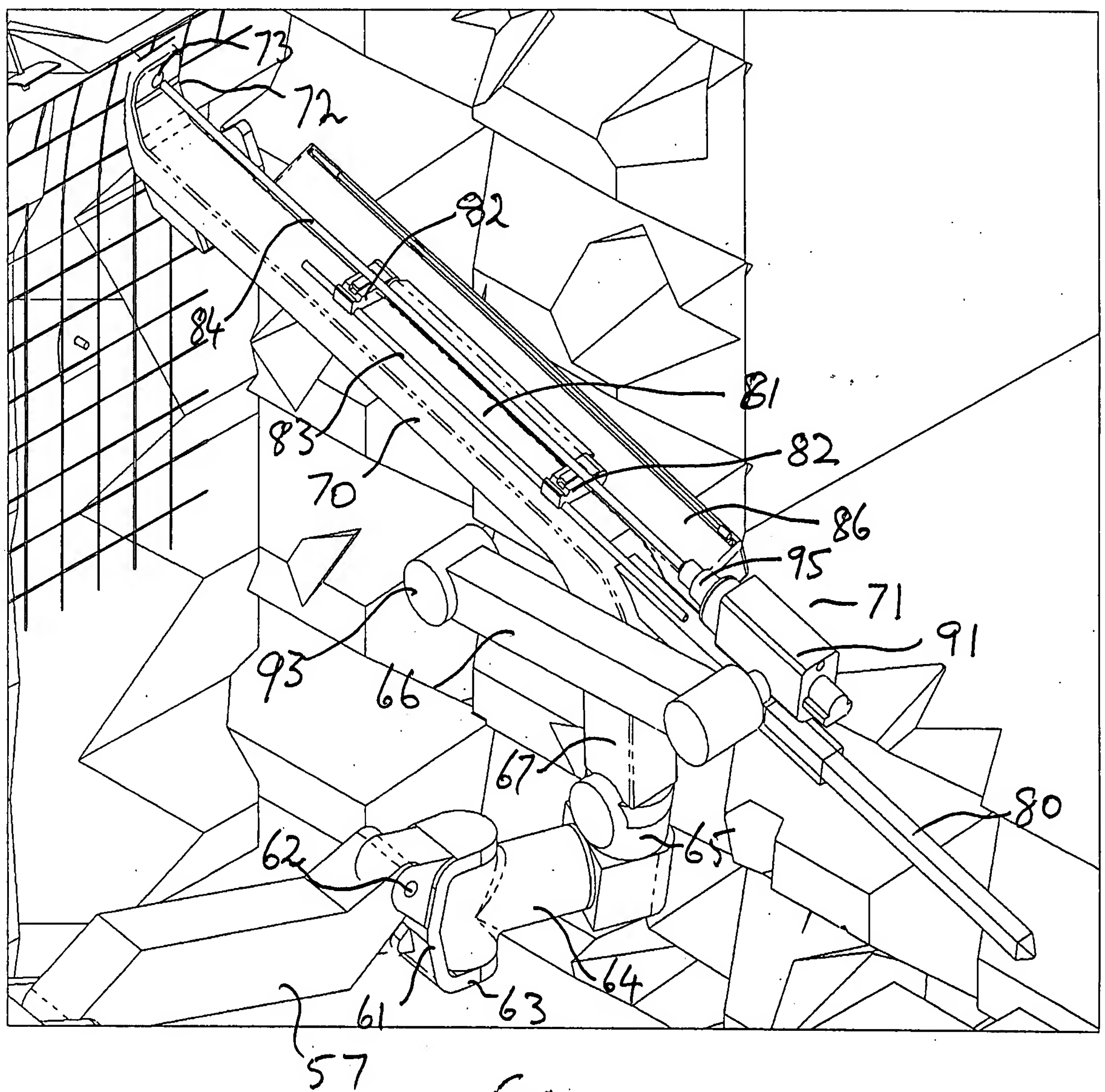

FIG 11

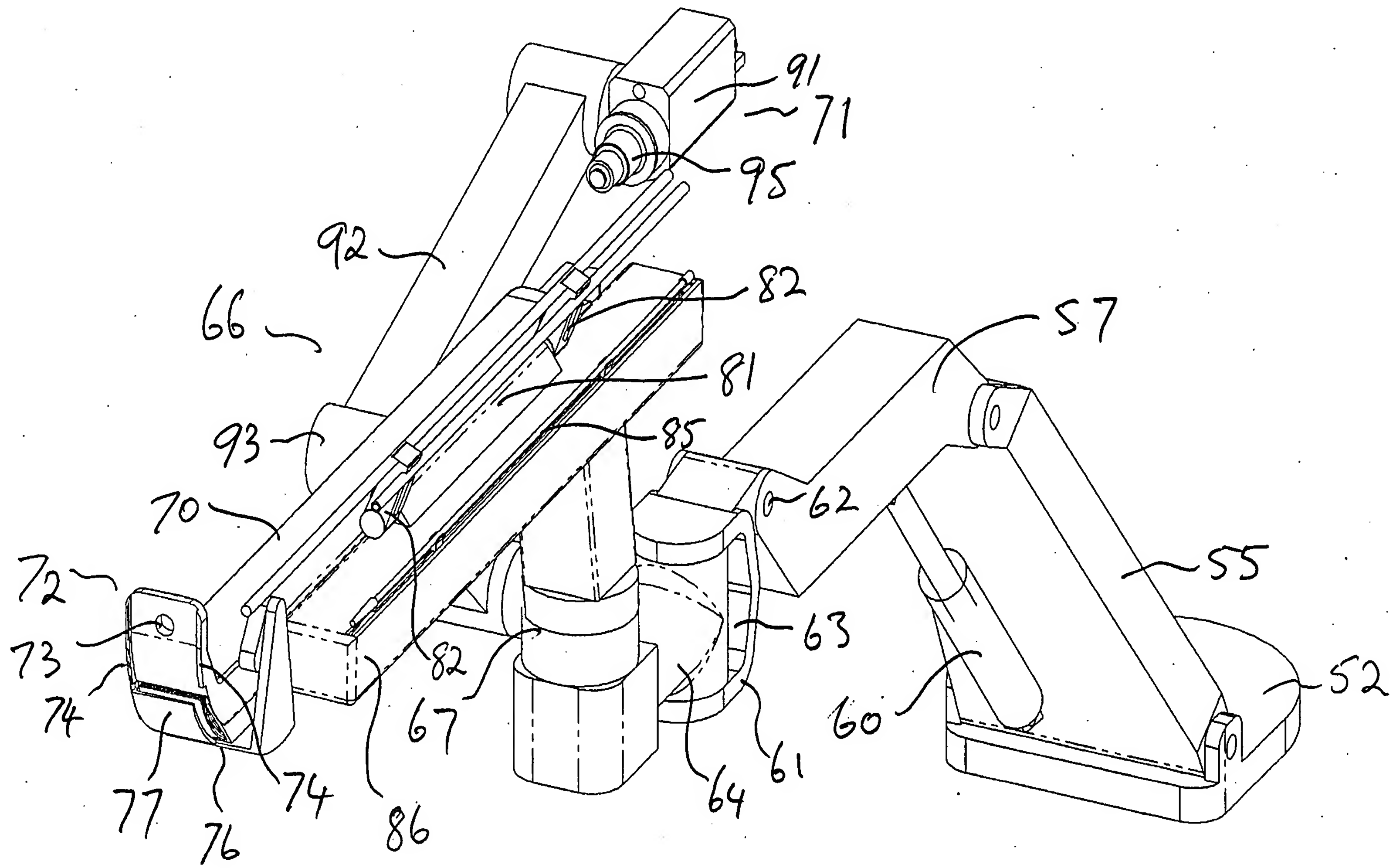
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Fig 12

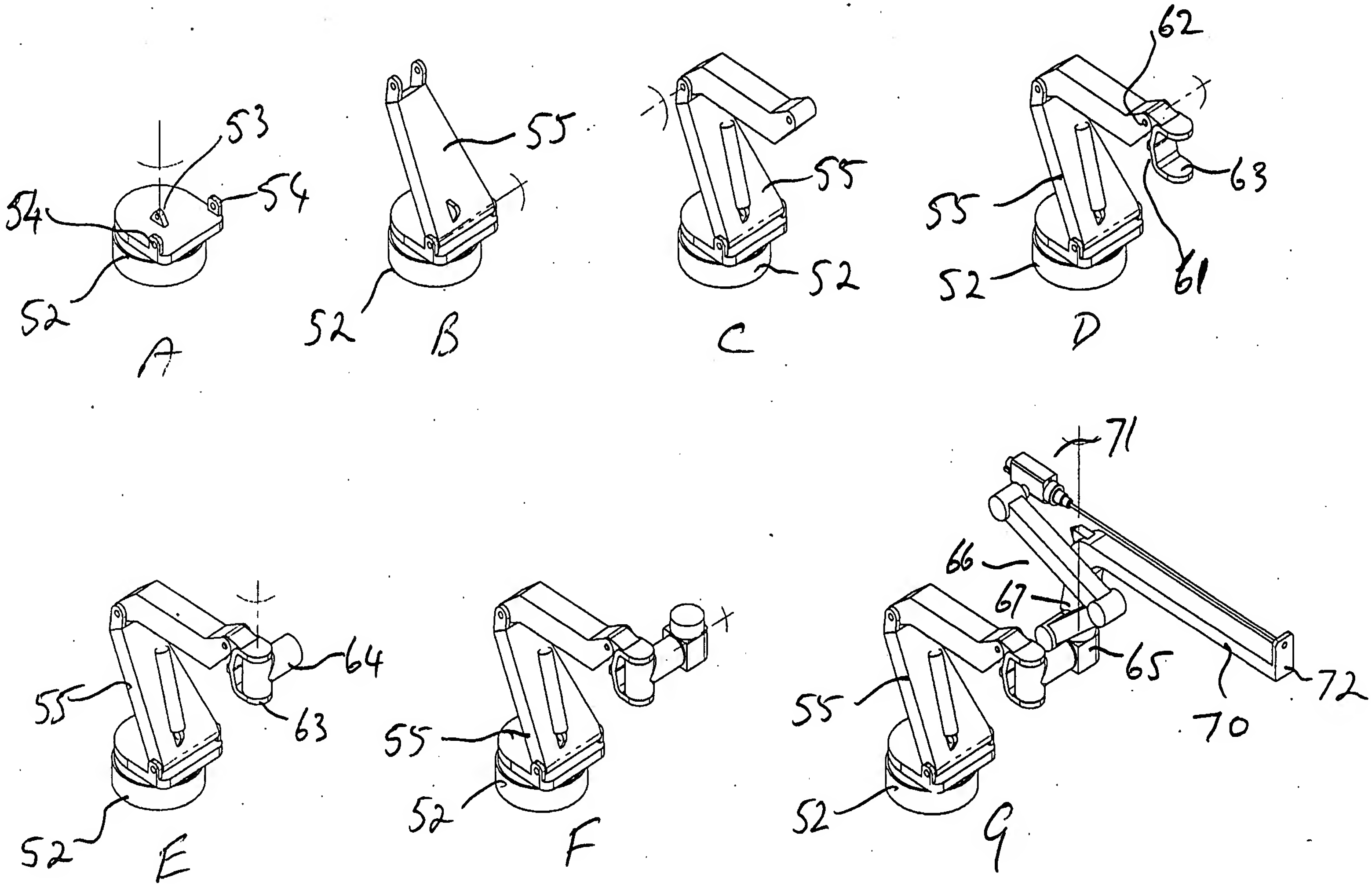

FIG 13 A-G

7-AXIS MANIPULATION OF BOOM ASSEMBLY

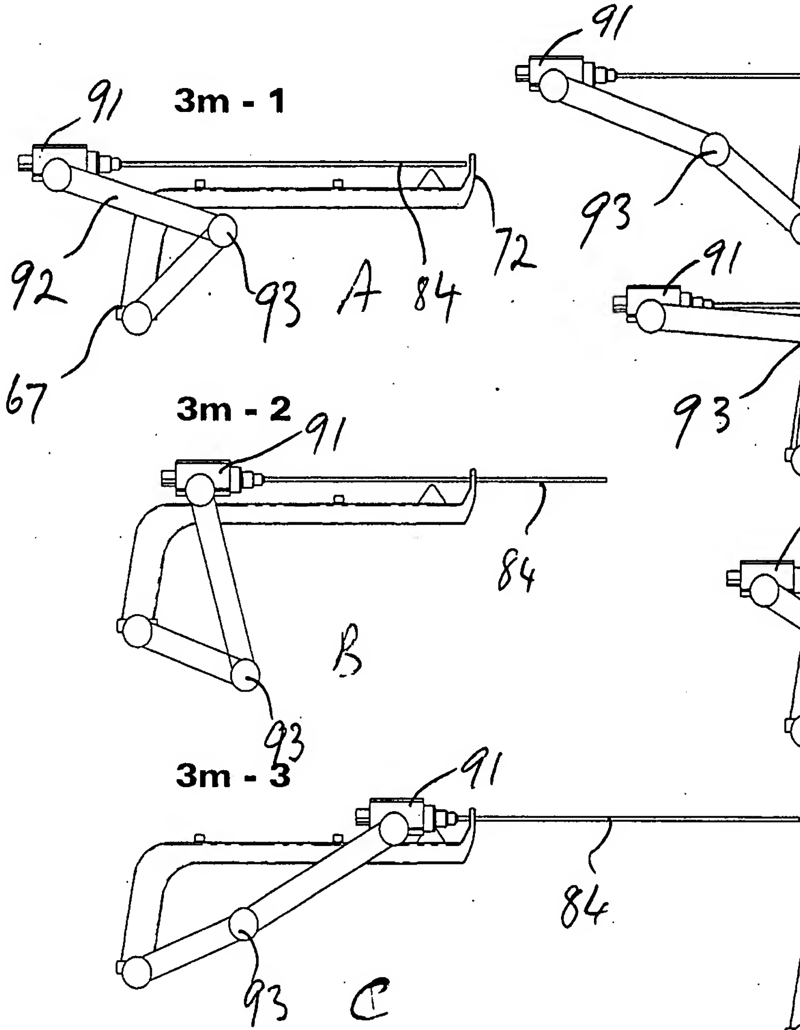

FIG 14 A-C

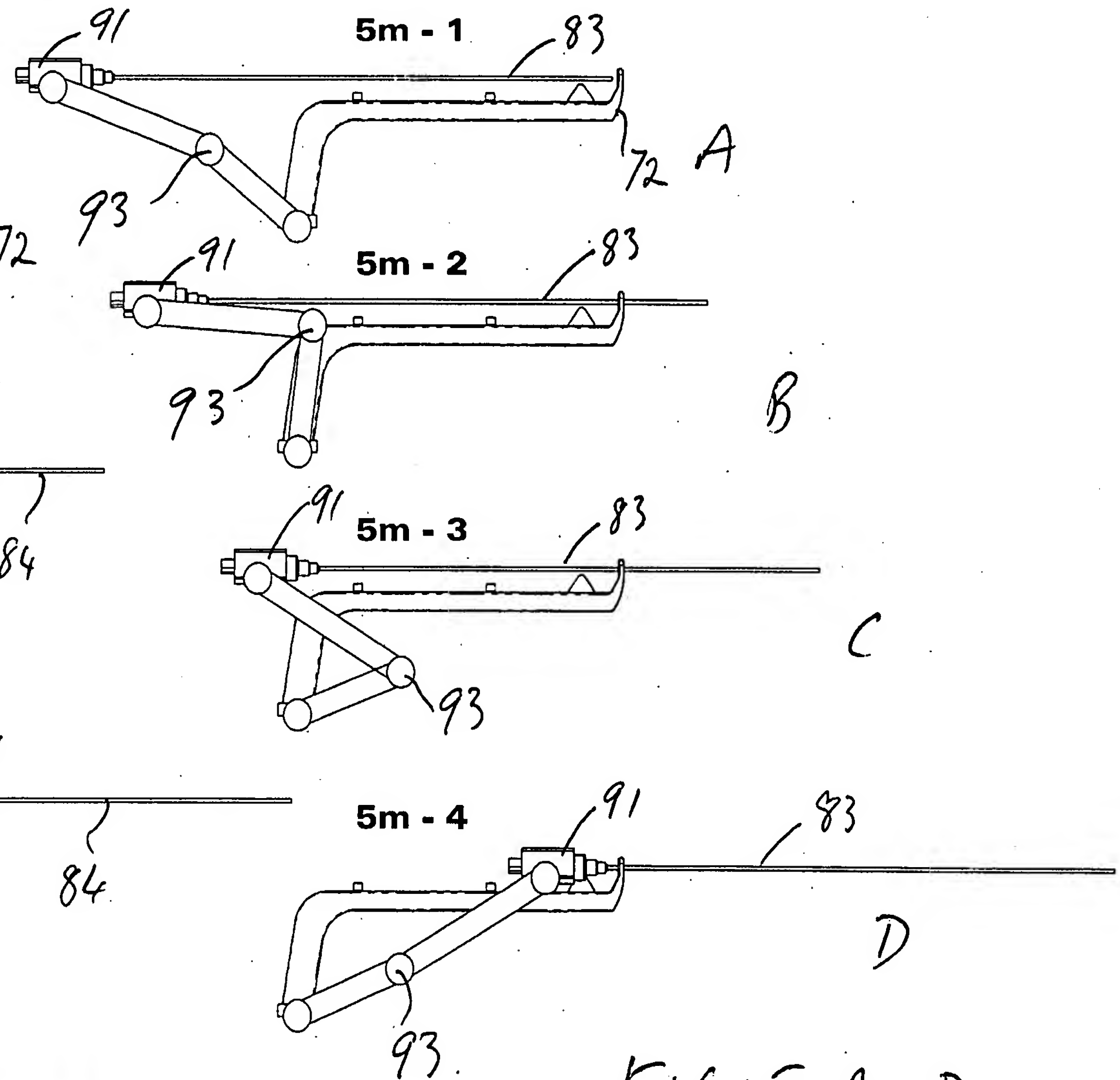

FIG 15 A-D

~~FIG 14~~

DRILL LINKAGE ARRANGEMENT

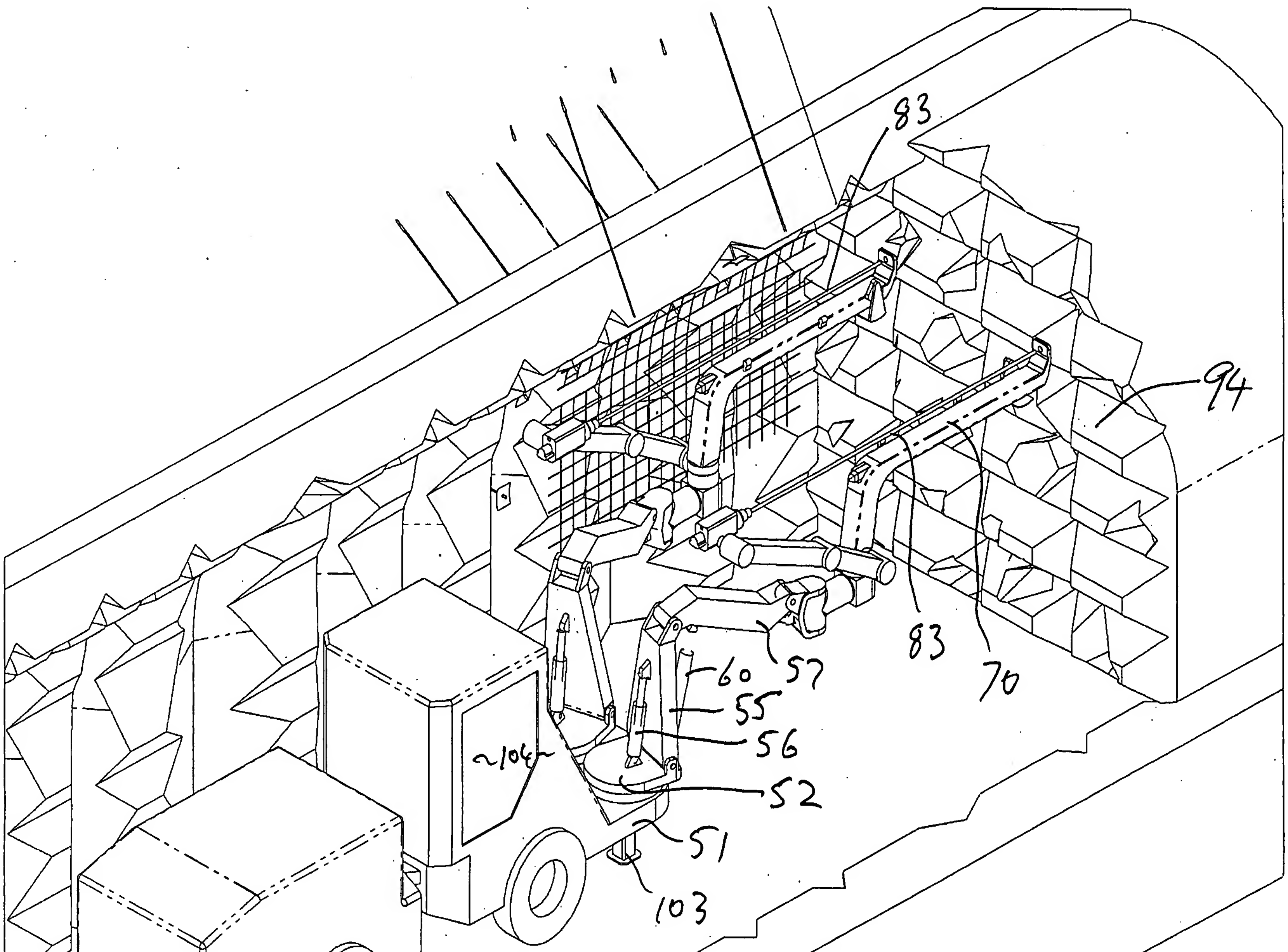

FIG 16

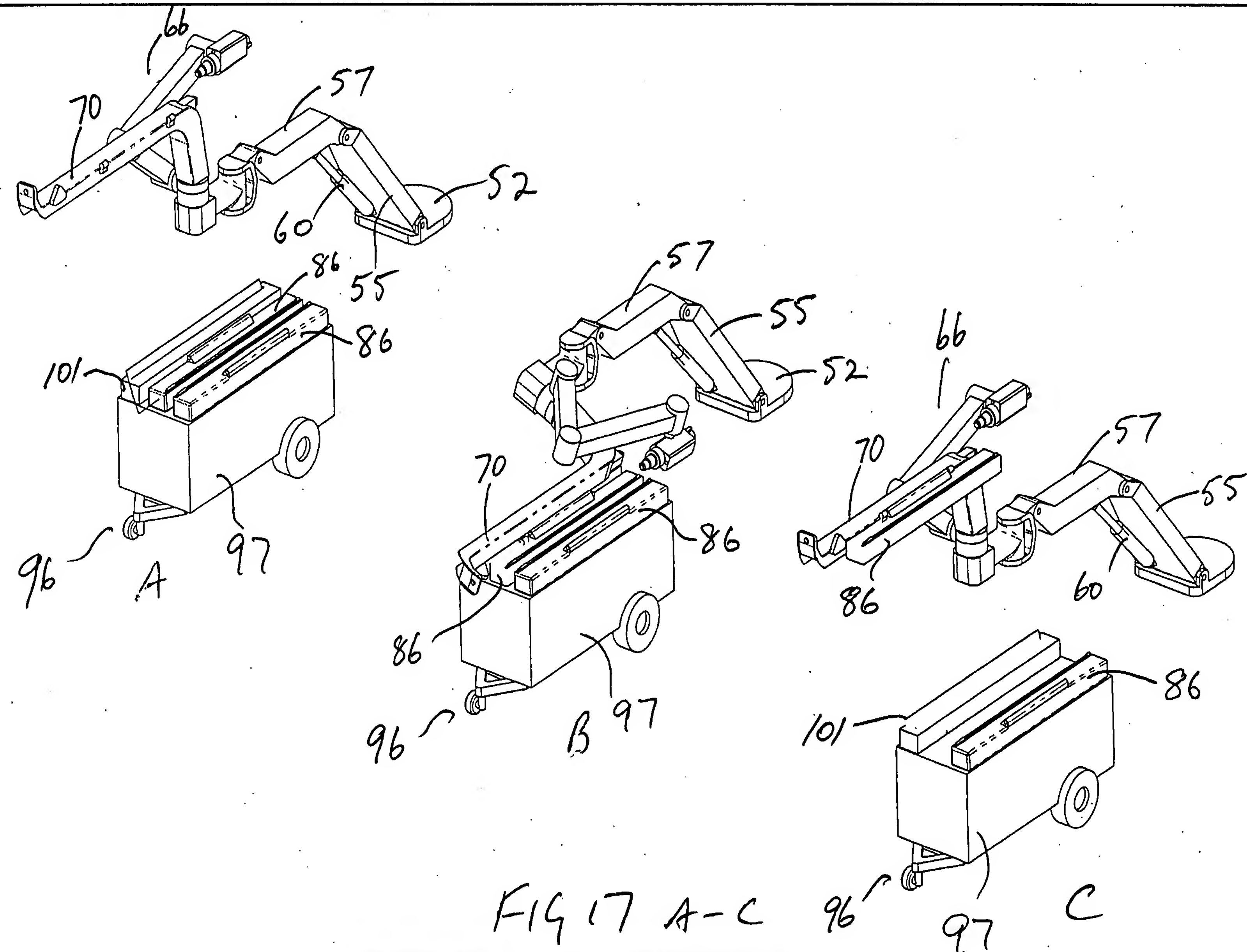

FIG 17 A-C

PICKING UP BOLT MAGAZINE

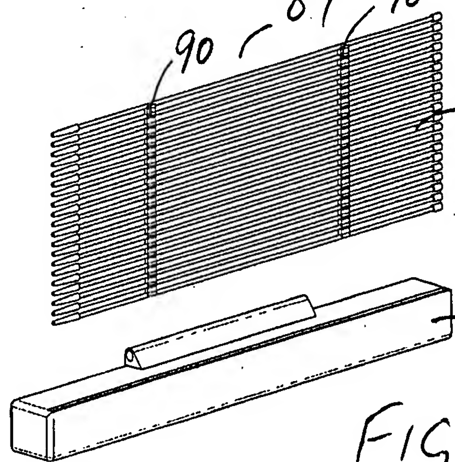

FIG 18

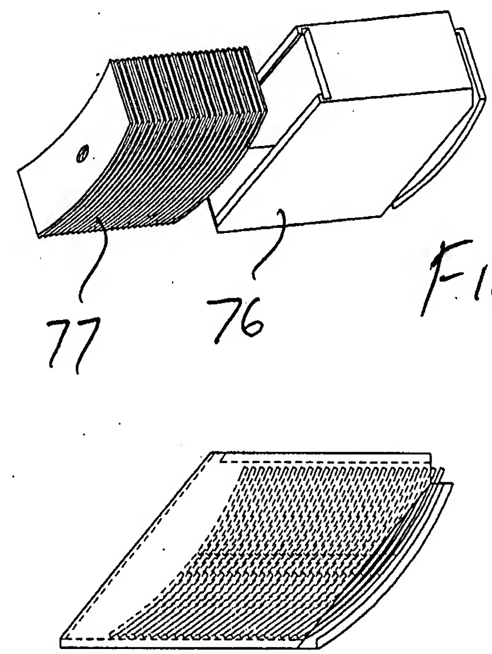

FIG 20

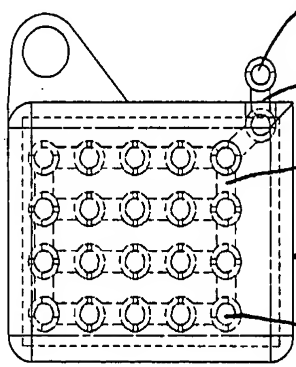

FIG 19

BOLT AND WASHER PLATE MAGAZINES

~~FIG 18~~

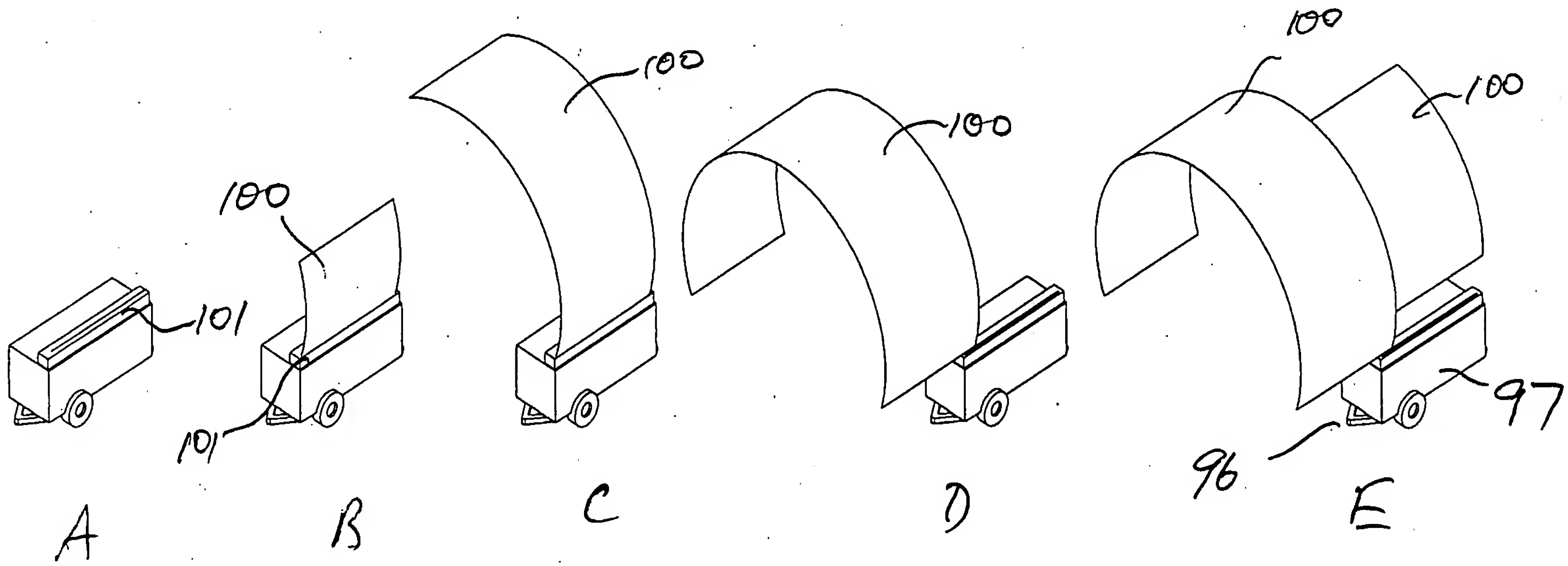

FIG 21 A-E

MESH TROLLEY

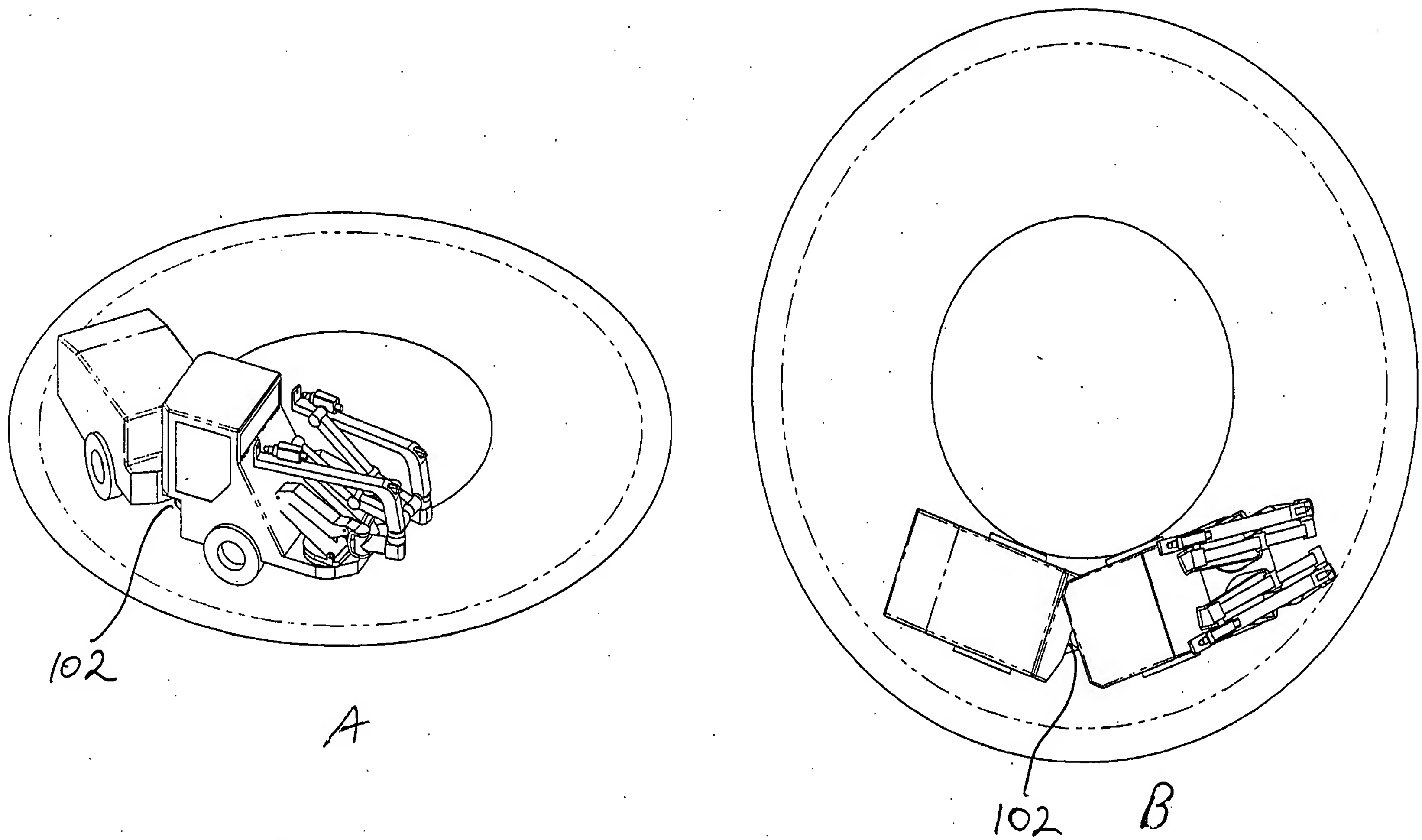

Fig 22
COMPACT TRANSPORT CONFIGURATION